STRATEGY RESEARCH PROJECT

THE "ARMY AFTER NEXT": INTEGRATION OF MICROCHIP TECHNOLOGIES

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The "Army After Next": Integration of Microchip Technologies

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ABSTRACT

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This study focuses on maximizing the integration of evolving microchip information processing technologies into our weapon system modernization process in support of the "Army After Next". It provides a conceptual framework for recognizing the roles industry will play in the modernization of the Army after next. The study then identifies and describes issues related to the interfaces of the military and industrial base. It finally explores the best ways and means to exploit the rapid advancements in microchip technologies.

TABLE OF CONTENTS

To protect and further U.S. global interests, DoD must maintain superior technological, industrial, and military capabilities for shaping the future.[1] With each new generation of microprocessors, the ability to rapidly process larger volumes of data into information increases exponentially. The microprocessor is revolutionizing the way society lives, so too can it radically alter DoD future war-fighting capabilities. It is revolutionizing industrial society today by complementing brainpower with the instantaneous power of electronic computation.[2] Computing capacity increases ten-fold every 3-4 years; further, the costs of acquiring this emerging technology are dropping at even faster rates. This technology likewise produces even faster, more capable, microchip-based products. DoD is thus challenged to find ways to incorporate these advancements into military and relevant commercial products. This study provides a conceptual framework determining the roles industry will play in the modernization of the Army after next. It identifies and describes issues related to interfaces between the military and industrial base. Finally, it explores the best ways and means to exploit the rapid advance of technology within the logistical support process.

THE ACQUISITION SYSTEM

World War II demonstrated the need for advanced high-technology industries, driven by the urgency to assume Allied victory. This national defense-industrial linkage began early in U.S. history during post-revolutionary times, when the need for interchangeable rifle parts hastened the development of repeatable manufacturing processes.[3] During the Cold War, the nation relied upon industry to produce technologically superior defense systems to offset the Soviet Bloc's numerically larger forces. The strategy of containment required DoD to maintain a strong, ready, and well-equipped military that was flexible and able to leverage its inherent mix of advanced technologies to overcome the numerical odds.[4]

Currently, our greatest strategic challenge is to compress the time it takes to make an informed decision. This quickening of the pace of change has become so extensive and extreme that time must now be considered as a critical factor in the modernization of this nation's forces for future conflicts. For example, the 8088 Intel microprocessor used in the Patriot missile, which

symbolized U.S. high-technology defense systems during the Gulf war, is already four generations old.[5] Since it currently takes at least ten years to field a weapon system, obsolescence actually precedes fielding the system! Once fielded, only a major change of threat or design failure will necessitate upgrading the system. With the rapid advances in micro-technology, it is only a matter of time before DoD will have to mandate a common command and control communication system. It can no longer afford to expend the resources required in developing a new command and control communication system. Modernization through spares offers an affordable alternative in the current fiscal environment.

The Gulf War demonstrated that high-tech weapon systems work. However, a multitude of logistical and operability issues must be resolved in order to capitalize their increasing costs. The services need more than ever to combine resources and focus on developing a joint command and control platform, direct attack munitions, and advanced strike technologies that are not frozen in design.[6] All systems must share common modular processing systems based on form, fit, and function configuration standards. On the commercial side, products are constantly improved in order

to stay competitive. Industry uses virtual reality design, just-in-time inventories, plug-and-play modules and other flexible manufacturing practices to improve their products as rapidly as possible.[7] These improvements are passed on as upgrades in the replacement-and-repair life cycles. DoD should carefully develop partnership agreements that leverage current commercial practices, rather than the current practice of freezing designs and making block incremental changes. Acknowledging the government's role in encouraging pre-competitive technology development, DoD must promote dual-use technologies and must support industry-led consortia. Such initiatives will enable DoD to shape and capitalize on recent dramatic technological advances.[8]

In cases where commercial products require adaptation for military use, DoD should consider long- and medium- term cost sharing initiatives to offset the costs associated with the deployment of new manufacturing technology by promoting the integration of military advancements into commercial production.[9] Integrated product teams-comprised of operators, engineers, and manufactures need to address modernization and logistical support issues in the development of this command and control system.

Whenever possible, Battle Labs, Advanced Technology Demonstrations, and Advanced Concept Technology Demonstrations must be used in the approval process. DoD and industry must take more proactive roles in identifying specific information-based core architecture this country is willing to develop jointly in support of both global market and military dominance far into the future. DoD can no longer depend on the shrinking defense industrial base to provide it with the "newest and best" at its own expense. DoD is no longer the best or most favored customer of American industry, which is now focused more on the global marketplace.

Industry, on its own, has already enjoyed limited successes implanting computer chips into cockroaches, as well as implanting rats' nerves into silicon interfaces. Advances in biotechnology fusion are paving the way for tomorrow's commercial robotic systems.[10] However, if DoD does not change the way it modernizes weapons platforms, it may eventually build a robotic system that is controlled by the equivalent of an 8088 microprocessor.

DoD must fundamentally reengineer and streamline its infrastructure and support structures to take advantage of the

revolution in business affairs occurring in the commercial world. DoD needs to design, test, build, and retrofit its command and control systems faster. We must focus on the future, always seeking creative ways to overcome budget shortfalls. Only through such efforts can we realize the cost efficiencies necessary to recapitalize a force[11] in which electronics are becoming increasingly critical to the performance, weight, size, reliability, interoperability, maintainability and cost of military systems.[12] This technological revolution will have a definite impact on current war-fighting concepts and force structures.[13]

MICROCHIP - CENTER OF GRAVITY

The commercial sector is focusing on building faster and smaller sensors, processors, storage and retrieval systems. These state-of-the-art technologies are then embedded into products and marketed at such a pace that it is impossible to remain in the lead for more than one year. For example, Intel is testing a totally new approach to boost the storage capacity of "Flash Memory" chips, the circuitry that enables microchip based devices to hold information even if they are turned off. The high-tech

industry, having exhausted more conventional means, is coming up with new creative solutions to one of today's most vexing challenges: how to squeeze more technology into a thumbnail size silicon chip.[14]

Such microchips can be found in appliances, vehicles, medical devices and a myriad of other commercial products specifically designed to attract new markets. On the other hand, defense requires more investment in information systems and less in the industrial era configurations of tanks, planes, and ships.[15] It should come as no surprise that the contemporary instruments of warfare bear a striking resemblance to those of thirty years ago. The tanks, planes, and ships of today have certainly improved, yet they are still the same basic types of systems, although their command and control has increased through the microchip.[16] The issue is no longer who can build the "best" – rather the competitive advantage goes to the one that makes a smarter system with improved communication and processing capabilities the fastest. This competitive advantage is evident in the effectiveness of smart weapons, which have successfully offset reductions in our munitions programs. Industrially designed sensors that detect nuclear, chemical, biological and security

threats provide around-the-clock surveillance as forces are reduced. However, these highly advanced systems have little commercial application, which means DoD must depend more heavily on its own investments in research and development.

SCOPE AND LIMITATIONS

How can DOD use the latest microchip technology to improve today's command and control of multiple weapon system platforms? How can it accomplish this modernization in view of current and anticipated budgetary constraints? First, to support the modernization process, DoD must build a federal acquisition process that encourages military partnerships with industry.[17] DoD is in the process of refurbishing, replacing, and upgrading equipment dating back to the 1940's. Not all military equipment needs to be completely replaced. In areas like air-to-air combat, the U.S. has an overwhelming lead. In many cases refurbishing an existing weapon platform, with a modest upgrade to its avionics, munitions, fire control systems and communications technology would widen the overall U.S. lead.[18] Gradual adaptation, rather than wholesale rebuilding of defense, may be a wiser way to modernize.[19] Adaptation allows DoD to stay

current until drastic breakthroughs in technology dictate a new major weapon system platform based on threat. Will DoD continue to rely on the current logistical system, given present budget trends?

Logistics now, more than ever, represents a subset of national power because it links the nation's industrial base with its military forces. DoD must turn to the civilian sector to perform functions such as engineering, warehousing, maintenance and material management.[20] Modernization of forces undoubtedly will lead to more extensive use of civilian contractors. New microchip based technologies will be cut into current production at the subcontractor level and incorporated into electronic modules to take advantage of just-in-time manufacturing processes. These upgraded electronic components will be immediately fed into the logistical support system. Such initiatives will sustain DoD's lead in developing dynamic weapon systems and space-oriented defense platforms; they will enhance modernization of current weapon platforms as well.[21]

Increased emphasis must be placed on using enhanced modular design that focuses on sensor data fusion, visualization,

distributed collaboration, high-speed uncooled electronics materials, single chips that integrate mechanical and electrical devices, intelligent agents that act in accordance with operator-defined purpose, sensors to exploit untapped sections of the electromagnetic spectrum, and biomimetics.[22] These enabling technologies can be logistically infused into today's command and control systems by using industry's modular "Plug and Play" component replacement concept. Ideally, each component would be modularly constructed with upgradable circuit cards and programmable microchip components capable of functioning in a multitude of communication and data-processing roles. Think of these micro-processing components as a power source, like common batteries are to a flashlight. Batteries are perfect examples of "Plug and Play" components that conform to a set of dimensions (form, fit and function) and are commercially available and easy to install at the operational level.

I. THE INDUSTRIAL INTERFACE

What will the future strategic environment be like? Globally, companies are forming into multinational, trans-national corporations and commercial alliances in order to shape future

markets. As corporations span the globe, they do not seek to deliver a single product or a single service, but to deliver total service packages.[23] Some of these "Fortune Five Hundred Corporations" already have worldwide command and control distribution chains; likewise, their maintenance and training centers are all supported by vast electronic networking systems. This ongoing revolution in business affairs is leading to reductions of stockpiled goods by means of just-in-time inventories. High velocity logistical distribution systems support just-in-time component requests. IBM and Honeywell depend on these high velocity distribution systems to support their 24-36 hour global customer support maintenance contracts. Hardware problems are quickly diagnosed; they are repaired with plug-and-play components. Smaller companies likewise take advantage of established distribution chains by using UPS and Fed-Ex in support of their business goals.

Industries are exploring ways to make their production lines more flexible in meeting customer demands. In the production of electrical modules, systems boards are designed with sockets that can accept a mixture of microprocessors, memory chips, and circuit cards that fulfill the functional demands required by the

customer. These sockets are also configured to accept future upgrades by design. This allows today's customers to order customized options that reflect the latest technology available during a given assembly processing cycle. Tomorrow's customers will be able to interface with engineering to influence component design, which will then be passed to production and plugged in during assembly. Industry will be positioned to gain technological and design insights from these personalized orders. Resulting enhancements can then be passed on to the vendors, enabling producers to offer past, present and future operators the newest and best technology available. These upgraded components will be made available through local service centers as replacement components in support of the modernization process. The computer industry, in particular, is already applying these modernization concepts.

To streamline the procurement process, DoD is currently undergoing its own revolution of business affairs called "Acquisition Reform". In order to keep pace with technological advancements, the services seek first to acquire commercial off-the-shelf components in support of the modernization process. DoD's research and development efforts, in part, focus on adapting some of these off-the-shelf components for use in

hostile environments. Advanced concept research cells search for innovative solutions to digitize the future battlefield in order to gain command and control over all the assets in an operational area. Unfortunately, R&D funding levels limit the development of these concepts up to and including a working prototype. The project is then shelved for future application if no immediate threat warrants continued development. Today, 38 percent of overall DoD investment goes to applied research; 46 percent to advanced technical development; and the remaining 16 percent is allocated to basic research. Two-thirds of the funding goes to industry, to non-profit organizations and to academic institutions; the remaining one-third goes into defense laboratories.[24] This distribution clearly reveals that DoD is becoming more dependent on the commercial sector to maintain its technological edge in support of national defense.

DoD, as is business, is developing joint operations, forming military alliances, standardizing weapons systems, reducing infrastructure, and streamlining logistics in pursuit of Joint Vision 2010's digitized battlefield concept. In the future, industry will assume an even more active role as an element of economic and military power. Industrial preparedness,

production, and delivery have already become the heart of modern warfare — ultimately more important than combat itself.[25] DoD may, unfortunately, enter future battle space with what it is procuring today. With each passing year, the operational costs associated with maintaining DoD's pre-modern communications equipment increases proportionally. Resources that would otherwise go into replacement and Research and Development are being consumed in maintenance. DoD must break this vicious cycle of stagnation, which binds it to the past and may jeopardize its future.

II. SECURITY

Current U.S. strategy calls for shaping the strategic environment to advance U.S. interests, maintaining the capacity to respond to the full spectrum of threats, and preparing for foreseeable threats.[26] Strategic security is dependent on a strong backbone of command, control, communications, computers, intelligence, surveillance, and reconnaissance. This informational backbone may be able to prevent electronic and physical interdiction, yet robust enough to process multiple data streams in real time. Many communication and hardware interoperability issues need to

be resolved before a standardized security system can be built.[27] DoD needs an active modernization program designed to take advantage of new microchip technologies that answer these interoperability issues while maintaining data security well into the future.[28]

Unlike past modernization programs, DoD is now taking commercially developed solutions and integrating them into military products. Since this technology is readily available, a potential adversary with the money and expertise could develop counter-measures at the same rate DoD's weapons systems are being modernized. In the meantime, foreign competitors advancements could render this technology obsolete and vulnerable to attack.[29] For example, when supercomputers are readily available at affordable prices, any country with the wherewithal can obtain and design formidable weapons, no matter how "backward" they may be otherwise.

DoD must acknowledge that there will be increased pressures from our allies and future coalition partners to share U.S. technology to the extent necessary to ensure adequate military-to-military interoperability. However, such sharing makes it all the more

difficult to safeguard these technologies.[30] Instead of sharing sensitive hardware, DoD can provide an "information umbrella" to its coalition partners by sharing imagery and weather data, command and control integration services, simulations and other training tools.[31] Another option is to provide generic "Plug an Play" modules that can easily be programmed or physically modified to fit into their command and control systems. These modules would be given serialized identities that can be electronically rendered inoperable if security is breached.

III. APPLYING TECHNOLOGY IN THE MODERNIZATION PROCESS

MODERNIZATION THROUGH SPARES

In the commercial marketplace, companies can easily introduce new technologies into their production lines because they maintain configuration management control over design. Before a design change can be initiated, cost analysis and profitability impact studies that asses how the bottom line will be affected must be completed before implementation. On the other hand, DoD controls the configuration and makes design changes that are restricted by budget, not by profit considerations. Auditing agencies such as the DoDIG and GAO force large contractors to separate their

commercial and military production lines. They demand this separation to insure that all costs are recorded accurately; that in-line production and assembly processes are properly monitored; and that inventory ledgers are in balance for each defense contract. Within a government contractor's facility, military production lines are separated by service component, then further subdivided by weapons systems program, since, each contracting entity has its own agency rules and regulations to follow. It is far more complicated to introduce new technologies into governmental contracts than it may seem at first blush.

How can DoD leverage industry's ability to use advanced modeling and production techniques to rapidly integrate technological advancements into both commercial and military production lines? We need to design dual-use communication modules that reflect advances in processing of metals, embedded sensors, and adaptive control systems for composites and electronics in the production of command and control components. Vendors can produce additional components to sell as upgrades and replacement items. This proactive approach takes advantage of microchip advancements by getting them in the distribution pipeline as soon as possible. As companies boost the number of transistors on each chip -

currently at 7.5 million to 1 billion by the year 2011[32] - increases in processing power and speed can be incrementally phased into our communication and operating systems. Incredibly, Intel Corporation is working on a technological breakthrough that ignores Moore's 18-month Law. The new technology could in some cases double micro-processing power every nine months or faster, as opposed to the earlier 18-month cycle.[33]

Dual-use technology policy offers an essential means of achieving DoD's goal of moving away from separate defense and commercial bases to an integrated national industrial base.[34] DoD appears to be headed in the right direction as it seeks to remove the barriers between commercial and defense institutes. Moreover, as advanced technologies are adopted and improved by industry, the military also benefits. Roughly 70 percent of the Army's recent investments offer the potential for commercial use.[35] Successful integration of commercial and defense investments broadens technological applications, insures market-place dominance, shares costs, and yields more capable systems.[36] Even so, the risk of making these components available commercially to those with ulterior motives presents a threat to national security. To maintain command and control dominance over information and the

battlefield, system security measures must be built into these products at the microprocessor level as part of the development phase - not as an afterthought.

AUTOMATED SUPPORT

Logistics is the foundation of combat power. It provides the bridge that connects the national economy with our war-fighting forces. Joint integrating maintenance, transportation, health services, general engineering, and supply systems will balance the unity of purpose equation.[37] The requirement for rapid processing and secure transmission of large quantities of data multicast over distributed networks for heterogeneous C3I systems present a formable challenge. As interconnectedness increases, the electrical and physical links between commercial and military systems requires decision-based information systems designed to filter out unnecessary data traffic. As microchip technology continues to advance, filtering and translation functions, performed by intermediate servers, will be replaced by synchronization modules at the data source. All these modules interacting directly with the command and control system should provide both the military and commercial systems with a real-time

picture of the battlefield and should clearly indicate and anticipate logistical support requirements.

LOGISTICAL CHAIN

What does an integrated global logistical systems look like? Tomorrow's joint weapon systems will be supported directly by the weapon's producer. If the system goes out of production, then the role of the producer will change; the producer will become the component upgrade integrator for what will become legacy systems. As upgrades to the basic systems are made, upgraded components will be passed along as replacements that can be plugged into conforming expansion sockets. There will be little need for stockpiling large quantities of spare components because flexible tooling and manufacturing processes would produce the components from electronically stored blueprints. Blueprints that define the basic dimensions will facilitate plug-and-play interconnectivity with legacy systems. Built-in obsolescence of components caused by years of overstocking is a thing of the past, hopefully blown away by the winds of modernization.

Continued reductions in logistical pipelines depend on the development of fail-proof components modularly designed through "ultra-reliability" engineering. The development of metamorphic

components designed to serve a variety of missions and innovative enhancements at the nanometer scale will reduce the logistical battlefield footprint. Ultimately, replacement components must be designed to be installable at the organizational maintenance level in support of rapid battlefield repair.

IV. RESOURCING THE MODERNIZATION PROCESS

MODERNIZATION THROUGH SPARES

Experience shows that, as weapons systems age, they experience increased failure rates, maintenance costs rise, and the availability of repair components declines. Thus DoD, has no alternative other than to maintain larger inventories to offset anticipated shortages. This situation becomes increasingly expensive as time passes. Unfortunately, as operational costs increase, the amount of money left to fund research and development, new weapon system development, and modernization dwindles. Now rapid advancements in technology are rendering some systems obsolete before normal life cycles are complete. So how does DoD breakout of this never-ending cycle?

DoD must shift from individual part replacement to modular plug-and-play component configurations, using a standardized command and control architecture that can be replaced during maintenance cycles. Because replacement components are coming off hot production lines, continuous advances in technology can be integrated into these components and fielded immediately. DoD must mount a cooperative effort among the services and industry to identify which systems can immediately benefit from the integration of these essential technologies.[38] For example, the Defense Advanced Research Projects Agency program has historically invested in high-risk, high-payoff technologies such as Stealth, GPS, and night vision in the past; today it is providing micro-electro-mechanical and networking technology. This technology facilitates the integration of electronic and very small mechanical components into a single system, using semiconductor-processing technology. Potential applications include very small guidance systems, hand-held mass spectrometers for field-portable gas analysis, and new control surface technologies for air and underwater vehicles.[39] Through modernization, these types of advances will be integrated into a wider spectrum of weapon systems by plugging in these command and control components as system upgrades.

AUTOMATED SUPPORT

Industry use electronic networks to monitor their logistical systems. These logistical systems react to a customer's order by automatically scheduling production and assembly times; they initiate sub-component orders with vendors; and then they track shipping statuses. To stay competitive, computer-makers have discovered that the only affordable items to stock are monitors, cables, and Central Processing Unit (CPU) Shells with power supplies. As customer orders are received, the latest video and sound cards are plugged into multi-processor ready motherboards. Then CD-ROM's tape backup units, and other accessories can be plugged in regardless of brand name. The applied technologies used in these components and accessories advance at different rates, However, they are no longer as codependent on each other to work properly. Because of this independence, systems can be upgraded (modernized) with faster and more capable components as they become available. It is no longer necessary to purchase new completely configured systems in order to capitalize on new technologies. As components fail or become damaged, they can be replaced with upgraded subsystems that in some cases cost less, while delivering more than the original component.

Taking this one step further: Imagine designing a self-monitoring system that not only advises the operator of a probable system failure but also reminds the operator of a scheduled maintenance requirement, automatically orders the component, then tracks and reports the status of the requisition. In case of failure, it immediately initiates a search for the component. The search expands outward until the needed component is located or the nearest automated production line has been tasked to produce a replacement. If the number of failures exceed acceptable parameters, then an engineering team would be tasked to improve the component's durability.

LOGISTICAL CHAIN

DoD needs to shorten the acquisition process, streamline distribution, and strengthen the logistical chain. The first priority should focus on establishing <u>one</u> command and control communication standard that is designed to accept plug-and-play upgraded components. Mobile service centers, sophisticated networked diagnoses, and field repair facilities can then be designed in support of this established standard. Industry will have to assume the roles of a total support systems integrator, configuration management controller, and security designer in the modernization process.

V. CONCLUSION

DoD must exploit the full capabilities of the industrial base in order to retain our superior technological, industrial, and military capabilities.[40] Current policies offer three ways to retain these capabilities: First, DoD should collaborate with the industrial base to ensure that we take full advantage of industry's increasing agility.[41] Second, DoD should expand technology transfer programs through partnership agreements between the defense laboratories and the private sector.[42] Finally, DoD should Cooperative Research and Development Agreements to promote the transfer of dual-use technology between the private and military sectors.[43] Modernization through spares offers the ways and means to maintain superior war-fighting capabilities through the infusion of advanced microchip processing technologies into today's weapon system platforms. The cost effectiveness and subsequent logistical savings of these policies will continue to improve as command and control architectures are integrated into one system facilitating the use of standardized plug-and-play components.

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